SUBSTITUTE SPECIFICATION

METHOD FOR CALIBRATING COLOR IMAGE SCANNERS

CROSS REFERENCE TO RELATED APPLICATION

This Application Is A continuation-in-part of U.S. patent application Ser. No. 09/653,314, filed on 1 Sept. 2000, now abandoned, and entitled "Method For Calibrating Color Image Scanners".

FIELD OF THE INVENTION

The present invention relates to a method for calibrating a color image scanner, and especially to a calibration method for keeping a constant color scanning quality of an image scanner.

BACKGROUND OF THE INVENTION

Since the properties of the sensors (not shown) are different, before being sold, the colors of each image scanning system (for example, scanners, color copiers, etc) must be calibrated for assuring the correction of colors in the image scanning system.

Referring to Fig. 1, a schematic view of a conventional image scanning system. In the figure, the image scanning system 40 has a scanner body 42, and a cover 44. The scanner body 42 has a scan window 46, a driving unit 48 and an optic mechanical module 60. The scan window 46 serves to receive documents to be scanned (not shown). The optic mechanical module 60 has a detection circuit and a converting circuit (not shown) for scanning aforesaid document. The driving

unit 48 serves to drive the optic mechanical module 60 so as to travel under the scan window 46. In the conventional color calibration procedure, a calibration chart 50 with standard white color is installed on the surface of the scan window 46 in the image scanning system 40. When a conventional image scanning system 40 scans, the respective signal of the calibration chart 50 with a standard white color will be detected by the image scanning system 40 and it is determined whether this signal is within a standard range. Therefore, one can easily adjust the correction of the colors from the image scanning system 40 and thus the parameters of the related circuit can be adjusted. However, in the image scanning system, since the calibration chart 50 is a standard white color slice, it can not be used to exactly calibrate the three primitive colors, red, green, and blue. To an extent, a standard white color is formed by linear combination of the vectors of the red, green and blue colors, so the error in each primitive color can't respond correctly. Namely, in the image scanning system, even when a color calibration process is performed accurately, the quality of the output color can still not be assured. Therefore, when the user finds some faults in scanning an image, a manual adjustment to calibrate the colors of an image scanning system is required. Not only the cost is increased, but also the quality can not be well controlled.

SUMMARY OF THE INVENTION

Accordingly, the primary object of the present invention is to provide a method for calibrating a color image scanner. Thereby, the defect from the manual adjustment in the prior art is removed. In the present invention, a color calibration chart is installed on the surface of the scan window of a color image scanner. Then, according to the sensed signal of the calibration chart, a parameter, e.g.

gain, of a converting circuit of an optic mechanical module is adjusted with a feedback loop so that the quality of the output color from the image scanning system can be retained at a predetermined level.

Another object of the present invention is to provide a method for calibrating a color image scanner, the defect from the manual adjustment in the prior art is removed. The color of the image scanner can be calibrated automatically so as to improve the quality of the output image. And thus, it is performed without increasing cost, and is economical.

For reaching the objectives above, the present invention proposes a method for calibrating a color image scanner. A color calibration chart is installed on the surface of the scan window of a color image scanner. Then, according to the sensed signal of the calibration chart, a parameter, e.g. gain, of a converting circuit of an optic mechanical module is adjusted with a feedback loop so that the quality of the output color from the image scanning system can be retained at a predetermined level. Therefore, the defect from the manual adjustment in the prior art is removed and it is performed without increasing cost, and is economical.

The various objects and advantages of the present invention will be more readily understood from the following detailed description when reading in conjunction with the appended drawing.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic view of a conventional image scanning system.

Fig. 2 is a schematic view of an image scanning system according to the present invention.

Figs. 2a~c are schematic diagrams of calibration charts according to the present invention.

Fig. 3 is a detailed operative flow of a preferred embodiment of the method for calibrating the color image scanning system in compliance with the present invention.

Fig. 4 is an operative flowchart for adjusting gain in the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference to Fig. 2, a color image scanning system of the present invention is illustrated herein. The color image scanning system 1 is formed by a scanner body 2 and an upper cover 3. The scanner body 2 has a scan window 10, a driving unit 12 and an optic mechanical module 14. The scan window 10 serves to receive documents to be scanned (not shown). The optic mechanical module 14 includes image sensors and a converting circuit (for example, analog / digital converter) for detecting the document to be scanned and converting the sensed signal into a digital signal. The driving unit 12 serves to drive the optic mechanical module 14 so as to be traveled under the scan window 10.

The present invention is different from the conventional calibration method. In the present invention, a color calibration chart 16 is placed on the surface of the scan window 10, and then the sensed signal of the calibration chart 16 is used to calibrate the parameter of the converting circuit.

Please refer to Figs. 2a~c. There are three embodiments of the calibration chart 16. In fig. 2a, the calibration chart 16 has three primitive color regions 162,163 and 164, whose colors are red (R), green (G) and blue (B), respectively. These three colors need not be pure colors, i.e. not necessary to be saturated

colors. Further, the calibration chart 16 has a white region 161, which is used for shading as well known in the prior art.

The embodiment in fig. 2b is similar to that in fig. 2a. The only difference is that the colors of the three primitive color regions 162', 163' and 164' are cyan (C), magenta (M) and yellow (Y).

The embodiment in fig. 2c is also similar to that in fig. 2a. The only difference is that the calibration chart 16 only has a primitive color region 165, whose color is a non-saturated color or gray.

Please refer to fig. 3, which is a detailed operative flow of a preferred embodiment of the method for calibrating the color image scanning system in compliance with the present invention. As an example, this embodiment employs the calibration chart 16 with the primitive colors of red (R), green (G) and blue (B) shown in fig. 2A. The method includes following steps:

Step 103: scanning the white region of the calibration chart 16.

Step 105: reading data by using the image sensors on the circuit board of the optic mechanical module 14.

Step 107: converting data to R.G.B. value by using analog-to-digital converters (A/D converter).

Step 109: amplifying the maximum value in each pixel to 250~255 (the maximum region), wherein each pixel is represented by 8 bits in this embodiment.

Step 111: adjusting gain.

Step 113: scanning a color region of the calibration chart 16.

Step 115: reading data.

Step 117: converting data to R.G.B. value.

Step 119: summing the R.G.B. values respectively converted from the data read from the white region and the color region of the calibration chart 16, and further averaging the R.G.B. values thereof.

Step 121: calculating an averaged compensating value for scanning as described in more detail below.

Step 123: then the color image scanning system processes scanning and compensating the scanned image referring to the summed R.G.B. value and averaged R.G.B. value.

Please refer to fig. 4, which is an operative flowchart for adjusting gain in the present invention. In step 111, assume a sensed value of a pixel is v and the current gain is g, then the gain adjustment value is d. Therein, the value of d can be modified according to different situations. The step 111 includes the following steps:

Step 21: checking if the current pixel value exceeds the maximum value. If it exceeds, perform step 22. Otherwise, perform step 23.

Step 22: g=g-d.

Step 23: g=g+d.

Step 24: checking if the sensed pixel value v is in the maximum region. If v is in the maximum region, jump to step 26. Otherwise, perform step 25.

Step 25: adjusting the value d according to the difference between the maximum value and value v. If the difference is large, magnify the value d. Otherwise, minify the value d. Then, jump back to step 21.

Step 26: gain adjusting process is completed.

In the step 121 described above, the image sensors of the optic mechanical module 14 not only can respectively sense a unique color such as R, G or B, but also can sense a little optical power of other colors. This is due to the properties of the filter lens or the light source. Hence, the sensed values are still influenced by other optical spectrums. For example, if an image sensor is used for sensing red, it not only can sense the optical power of red, but also can sense a little optical power of blue or green. Consequently, if the sensed value is (R, G, B) and the real value is (r, g, b), their relation can be expressed as:

$$R = a_{11} * r + a_{12} * g + a_{13} * b + c_1 \text{----------} (1)$$

$$G = a_{21} * r + a_{22} * g + a_{23} * b + c_2 \text{----------} (2)$$

$$B = a_{31} * r + a_{32} * g + a_{33} * b + c_3 \text{----------} (3)$$

Therein, a_{ij} (i , j =1 , 2 , 3) are relative coefficients between the sensed colors and real colors, and c_1, c_2, c_3 are the minimum values that can be sensed (these values correspond to when the real color is black).

The equations (1)~(3) can be expressed by matrices as following:

$$(R、G、B)^T = A(r、g、b)^T + C \text{----------} (4)$$

wherein matrices A and C can be written as:

$$A = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \qquad C = \begin{bmatrix} c_1 \\ c_2 \\ c_3 \end{bmatrix}$$

Since the real colors in the calibration chart 16 are known, we can use the sensed colors and real colors to obtain the matrices A and C.

Moreover, due to the obtained transfer function (4), we can get the correct colors in the step 123 by using the scanned image and the following inverse function:

$$(r、g、b)^T = A^{-1}((R、G、B)^T - C)$$

Thereby, the correct color image can be obtained.

In summary, the method for calibrating a color image scanner according to the present invention has the following advantages:

1) The defect from the manual adjustment in the prior art is removed.
2) The colors of the image scanner can be calibrated automatically so as to improve the quality of the output image.
3) The method of the present invention is performed without increasing cost, and is economical.

Although the present invention has been described with reference to the preferred embodiments, it will be understood that the invention is not limited to the details described thereof. Various substitutions and modifications have been suggested in the foregoing description, and others will occur to those of ordinary skill in the art. Therefore, all such substitutions and modifications are intended to be embraced within the scope of the invention as defined in the appended claims.